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CONTRACT NAS 8-35817

STUDY OF HIGH PERFORMANCE ALLOY ELECTROFORMING
TWELFTH MONTHLY TECHNICAL PROGRESS NARRATIVE

NOVEMBER 26, 1984 TO DECEMBER 21, 1984

ELECTROFORMING OPERATIONS DEPARTMENT

BELL AEROSPACE TEXTRON

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BY

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JANUARY 7, 1985

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STUDY OF HIGH PERFORMANCE ALLOY ELECTROFORMING

ABSTRACT

The nickel-manganese experimental electrolyte was hydrogen peroxide treated and carbon purified for removal of residual sodium saccharin and related organic decomposition products from the plating of previous test panels. The saccharin additive had been used to reduce stress where high concentrations of manganese and high pulse peak current densities had been used. Presently we are electroforming a large quantity of nickel-manganese alloy plates containing 0.35 to 0.40 percent by weight manganese for testing to supply data to fill the gaps shown in the mechanical property data table supplied in the previous progress report. The aluminum billet required for the machining of the subscale MCC mandrel is now in house.

I. INTRODUCTION

The purpose of this work is to develop and demonstrate a system for electroforming materials with improved strength and high-temperature properties. The Space Shuttle Main Engine employs a main combustion chamber (MCC) where final combustion of propellant at high temperature and pressure takes place. This critical component must be structurally supported by a nickel-base alloy jacket. Producing this jacket from formed wrought metal segments requires numerous weldments which alter the mechanical properties of the base metal through heat affected zones. This requires thickening the alloy where joints are to be made to meet the structural requirements of the shroud. The use of electroformable alloys with great strength would have the potential for simplifying fabrication procedures for structural jackets and reducing overall weight by removing weldments. Such an electroformable alloy might also afford a possible use in advanced engines where light weight and good strength at high temperatures are necessary.

II. TECHNICAL PROGRESS SUMMARY

A. Task I - Literature Survey (Phase A) - Completed previously.

B. Task II - Alloy Characterization and Optimization (Phase A)

Data furnished in the report for the previous period indicated that excellent mechanical properties at room temperature, 149°C (300°F), and 260°C (500°C) were obtained in nickel-manganese electroformed alloy containing 0.358 % Mn (Sample NM-25), 0.488 % Mn (Sample NM-16), and 0.660 % Mn (Sample NM-15). The latter two specimens were electroformed at 30 amperes per square foot; NM-16 was pulse plated at a 50% duty cycle and NM-15 was conventionally plated. Sample NM-25 was pulse plated at a 50% duty cycle; however, a lower average current density of 20 amperes per square foot was employed. Also the bath from which Sample NM-25 was produced contained 60% more manganese than that from which Samples NM-15 and NM-16 were electroformed.

Sample NM-15 exhibited the best mechanical properties over all temperatures of interest. Since this alloy was deposited with conventional non-pulsed current, it is suspected that use of similar plating conditions on a chamber simulation will show current density (and concentration polarization) variations leading to regional fluctuations in manganese content - hence, the mechanical properties may vary extensively.

Sample NM-16 was pulsed and exhibited good mechanical strength but borderline ductility for the heat treatments applied. Again, the average current density was 30 amperes per square foot. We don't particularly like an average current density this high since it leads to greater diversities in regional current densities on complex shaped hardware. This leads us to expect that the electroforming parameters used to produce Sample NM-25 will provide the more consistently uniform alloy chemistry on the MCC simulator.

We are currently producing a series of nickel-manganese electroformed plates similar to NM-25. On some of these we will make minor variations in an effort to "tune" the alloy composition for evaluation of heat treatment on mechanical properties. As examples of this tuning we will examine pulse frequency increases within the same 50% duty cycle and study the effects of minor duty cycle variations such as 40% and 60%. Sufficient material will be available to explore various heat treatment affects on mechanical properties. This work had been planned originally as Task I, Phase B; however, we have strong feelings that that work is more appropriate at this point. We have discussed this with the MSFC-COR and there has been no objection to shifting this task to this point in the contract.

The 42 gallon bath used to produce all nickel-manganese samples to date was hydrogen peroxide treated and carbon treated to remove a stress reducing agent (sodium saccharin) employed at the time Samples NM-30 through NM-35 were electroformed. Incomplete removal of all organic by-products was incomplete on the first treatment. A second treatment appeared to remove all organics. Partl production is again in progress.

C. Phase B - MCC Subscale Mandrel

The 6061 Aluminum billet to be machined into a two-piece mandrel is in-house. No machining work will be started until a design sketch has been submitted to MSFC and approved.

Since the mandrel can be separated and reused, we plan to electroform several stuctural shells in the order of 1.27 mm thickness to map the manganese variation from the throat region to the sections approaching the coolant manifolds. By producing one such structural shell without pulsing and the remainder of shells with the one (or more) pulsing parameters considered appropriate to best mechanical properties. This will allow us to evaluate pulsing effects on composition uniformity over a complexed surface and to compare to a non-pulsed baseline.

III. CURRENT PROBLEMS

No technical problems are currently surfaced. It may be necessary to request a scheduled completion change - perhaps to the end of August 1985; however, sufficient funding appears to exist.

IV. WORK PLANNED

1. Continue reproduction of nickel-manganese alloy plates from condiditions used to produce NM-25, 26, and 27 with minor parameter variations considered to improve ductility and manganese unifority.
2. Screen above panels for suitability for heat treating - may use hardness measurements as a guide.
3. Develop alternate subscale mandrel designs for Phase B and present to MSFC for discussion/concurrance.

V. FINANCIAL DATA

See attached NASA Form 533P. The financial figures include the correction of a labor charge for metallurgical work which results in a reduction of hours and dollars from the previous month. Very few costs were incurred during December due to the fact that alloy plating bath purification was in progress over a three week period. This is not a labor intensive operation.

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NASA APPROVED SCHEDULE

NASA Ames Research Center

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| 1. PROCUREMENT OFFICE GEORGE C. MARSHALL SPACE FLIGHT CENTER, MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812 | | 2. FROM: NIAGARA FRONTIER OPERATIONS BELL AEROSPAC, TEXTRON POST OFFICE BOX 14240, BUFFALO, NY 14240 | | 3. FORM APPROVED Budget Bureau No. 104-R0011 | | 4. REPORT FOR PERIOD ENDING AND NUMBER OF OPERATING DAYS December 21, 1985(20 Operating Days) | |
|---|----------------|---|------------------------------|---|-------------------------|---|--|
| 5. DESCRIPTION OF CONTRACT | | 6. TYPE Cost-Plus-Fixed-Fee | | 7. CONTRACT NO. NAS 8-35817 | | 8. CONTRACT VALUE \$ 183,986 | |
| 9. SCOPE OF WORK Study of High Performance Alloy Electroforming | | 10. CUM. COST/HOURS THROUGH CURRENT PERIOD | | 11. CONTRACT NO. AND LATEST DEFINITIZED AMENDMENT NO. L. O. McLean | | 12. PURCHASE LIMITATION \$ | |
| 13. REPORTING CATEGORY | | 14. PLANNED VALUE OF WORK | | 15. CONTRACTOR'S ESTIMATED FINAL COST | | 16. TECHNICAL ASSESSMENT OF PROGRESS | |
| SCH. SCHEDULED Hrs. | ACTUAL Hrs. | COST/HOUR (\$/hr.) | SCHEDULE HRS. (\$/hr.) | COST/HOUR (\$/hr.) | 17. SCHEDULE AND STATUS | 18. TECHN. STATE | |
| SUB-TOTAL: | | Hours 1,427.2 | 1,246.1 | 1,246.1 - 181.1 | 3,204 | 40.5 | |
| | | Dollars 86,051 | 73,399 | 73,399 - 12,652 | 183,986 | | |
| FIXED FEE DOLLARS | | .5,482 | 4,676 | 4,676 | 11,721 | | |
| TOTAL FUNDING REQUIRED | | Hours 1,427.2 | 1,246.1 | 1,246.1 | 3,204 | 40.5 | |
| | | Dollars 91,533 | 78,075 | 78,075 | 195,707 | | |
| 19. INVOICE AMT'S BILLED \$ 11,721 | | | | | | | |